**S-CLASS ASTEROIDS: THE VIEW FROM THREE MICRONS.** A. S. Rivkin, *University of Arizona, Tucson AZ 85721-0092, asrivkin@lpl.arizona.edu*, E. S. Howell, *University of Puerto Rico, Mayaguez PR 00681-5000*, B. E. Clark, *Cornell University, Ithaca NY 14853-6801*, L. A. Lebofsky, D. T. Britt, *University of Arizona, Tucson AZ 85721-0092*.

S-class asteroids have been observed on a ''target of opportunity'' basis in the course of surveys dedicated to observing other classes of asteroids (Jones et al. 1990, Lebofsky et al. 1990 ,Rivkin et al. 1995). These S-class asteroids, the circumstances of their observation, and the reference in which they first appeared constitute Table 1. Eight asteroids have been observed, and as expected, none show an absorption feature at 3 $\mu$m indicative of water of hydration.

We have constructed 0.3--3.5 $\mu$m spectra of these asteroids by combining our 3-$\mu$m spectrophotometry with shorter wavelength studies (Zellner 1985, Bell et al. 1988, Murchie and Pieters 1996, Howell et al 1994a). We have found that the main-belt S-class asteroids observed have a 2.95-$\mu$m reflectance / 0.55-$\mu$m reflectance clustered very close to 1.40 (except 5 Astraea, whose value is 1.23 $\pm$ 0.05), while the two near-Earth objects (NEO) observed (433 Eros and 4179 Toutatis) have 2.95-$\mu$m reflectances of roughly 1.7 $\pm$ 0.1 times their 0.55-$\mu$m reflectance (see Figure 1).

The S-class asteroids have been interpreted as differentiated, stony-iron objects by some authors (Bell, et al. 1989), and as perhaps the ordinary chondrite parent bodies by others (Chapman 1996, Gaffey 1996). A major issue in this debate is the characterization of (indeed, even the existence of) any ongoing processes , which may be responsible for changing the spectra of ordinary chondrites to look like S-class asteroids (''space weathering''). If so, studies at 3 $\mu$m may help determine the nature of alteration trends by extending the continuum beyond regions where silicate absorption features may confuse the issue.

The fact that all but one of the main-belt S-class asteroids studied have such similar 2.95-$\mu$m / 0.55-$\mu$m reflectance ratios suggests that they all may share a common spectral continuum from the visible through the IR, upon which 1-$\mu$m and 2-$\mu$m olivine and pyroxene absorptions of differing strengths are superimposed. Furthermore, the observation that both near-Earth objects plotted here have higher 2.95-$\mu$m reflectances suggests that *if* the difference in continuum between the two NEOs and the main-belt S-class asteroids in the 3 $\mu$m region is due to ''space weathering'', then this ''weathering trend'' would tend to decrease spectral slopes and decrease reflectance in this region as the alteration progressed. In this interpretation, the majority of main-belt S asteroids studied here may have been weathered to completion, resulting in their common spectral points at 3 $\mu$m. The spectrum of 5 Astraea cannot be explained as part of this NEO $\rightarrow$ S asteroid weathering trend.

Figure 2 shows the spectra of two ordinary chondrites (OC), Goodland (L4) and Castalia (H5) along with selected asteroids from Figure 1. The meteorites are less reflective at 2.95 $\mu$m in these normalized spectra than any of the asteroids. If ''space weathering'' has altered the spectra of these meteorites to look like the main-belt S-class asteroids, then the ''weathering trend'' implied would tend to increase spectral slopes and reflectance in the 3 $\mu$m region as the alteration progressed. In this interpretation as well, the majority of main-belt S asteroids studied here may have been weathered to completion, resulting in their common spectral points at 3 $\mu$m. The spectrum of 5 Astraea now may be explained as an intermediate stage between ''unweathered'' (OC) and ''fully weathered'' (other main-belt S asteroids shown here). Here, however, the spectra of the two NEOs cannot be explained as part of this OC $\rightarrow$ S asteroid weathering trend. Possible explanations of this include the small numbers of NEOs observed, or possibly different mineralogies for the NEOs compared to the main-belt S asteroids.

*References:* Bell et al. (1988) *LPSC* **19**, 57. Bell et al. (1989) in **Asteroids II**, U. of A. Press, Tucson. Chapman (1996) *Met. Plan. Sci.* **31**, 695. Gaffey et al. (1993) *Icarus* **106**, 573. Gaffey (1996) *Met. Plan. Sci.* **31**, A47. Howell et al. (1994a) *Icarus* **111** 468. Howell et al. (1994b) *JGR* **99** 10847. Jones et al. (1990) *Icarus* **88**, 172. Lebofsky et al. (1990) *Icarus* **83**, 12. Murchie and Pieters *JGR* **101**, 2201. Rivkin et al. (1995) *Icarus* **117**, 90. Zellner et al. (1985) *Icarus* **61**, 355.

| Asteroid | Date | Class | Reference |
|---|---|---|---|
| 5 Astraea | Apr 1987 | Sp | 1 |
| 6 Hebe | Feb 1996 | S(IV)/Sp | 2 |
| 7 Iris | Dec 1995 | S(IV)/S | 2 |
| 18 Melpomene | Apr 1987 | S(V)/So | 1 |
| 243 Ida | Dec 1991 | S(IV)/S | 2 |
| 433 Eros | Dec 1995 | S(V) | 2 |
| 532 Herculina | Apr 1987 | S(III)/S | 1 |
| 4179 Toutatis | Jan 1993 | S(III)/SoS | 3 |

Table 1: Observing Circumstances. The class is the subclass of S asteroids to which the asteroid belongs based on the work of Howell et al. (1994b) and Gaffey et al. (1993). The references are keyed to the following: 1-- Jones et al. (1990), 2-- This work, 3--Howell et al. (1994a)

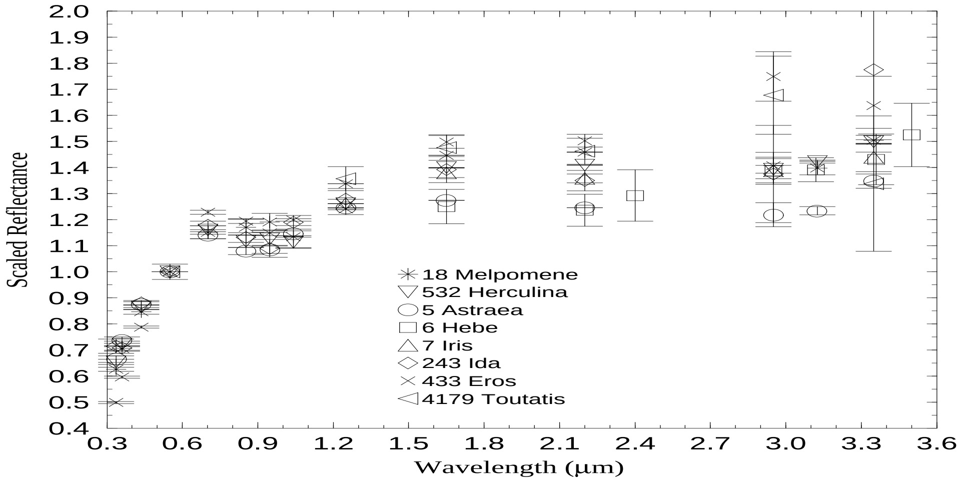


Figure 1: 0.3--3.5 $\mu$m Spectra of S-class asteroids and the meteorites Castalia (H5) and Goodland (L4), all normalized to 0.55 $\mu$m. Note that the near-Earth objects 433 Eros and 4179 Toutatis are more reflective in the 3 $\mu$m region than the other (main-belt) S-class asteroids, and that all the main-belt asteroids (save 5 Astraea) form a very tight cluster at 2.95 and 3.12 $\mu$m despite major differences among them in the 0.9--2.5 $\mu$m region. This suggests that these asteroids may share a common continuum, with spectral slope differences in the 1--2.5 $\mu$m region perhaps being only apparent. The 0.3--2.5 $\mu$m data for these asteroids are from Zellner et al. (1985) and Bell et al. (1988), the 1.25--3.5 $\mu$m data for the asteroids are from references as per Table 1.

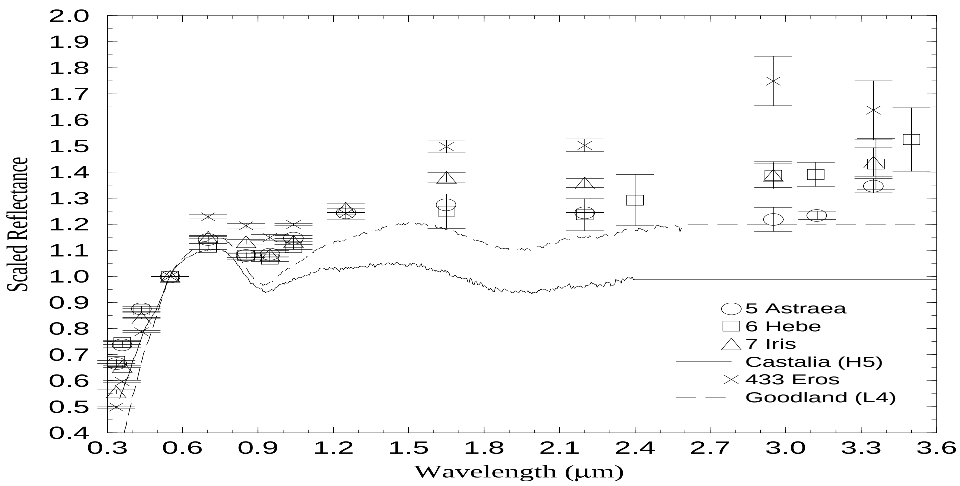


Figure 2: 0.3--3.5 $\mu$m Spectra of the S-class asteroids 5 Astraea, 6 Hebe, 7 Iris, 433 Eros and the meteorites Castalia (H5) and Goodland (L4), all normalized to 0.55 $\mu$m. Note also that both of the meteorite spectra have a flatter spectral slope than any of the asteroids, and that 433 Eros has a larger slope than than the main-belt S asteroids. This suggests any weathering sequence involving the S-class asteroids does not include both 433 Eros and the ordinary chondrites. The 0.3--2.5 $\mu$m data for these asteroids are from Zellner et al. (1985) and Bell et al. (1988), the 1.25--3.5 $\mu$m data for the asteroids are from references as per Table 1.